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PRELIMINARY REVISION OF THE FAMILIES PATELLIDAE AND ACMAEIDAE IN AUSTRALIA

By J. Hope Macpherson, M.Sc.

[Read 9 December 1954]

Introduction

Recent surveys of intertidal zonation in Australia have stressed the importance of certain groups of animals and plants as indicators both of littoral zones and as markers of biogeographical divisions. The desirability of obtaining constant conditions makes it necessary to carry out such surveys on areas of extreme exposure. Hence the animals and plants found are confined to those that can retain their hold on the rocks, even in the fiercest gales. The two families reviewed in the present paper have this ability and most of their members are very selective in confining their position to a limited vertical area (zone) within the tidal range.

Map I

The division of coastal areas into climatic "Regions" by Stephenson (1948) is a primary one of more universal application than the "zoological provinces" earlier established for Australia by Hedley and others. References to Map I will make it clear that the Tropical Region of Australia is composed of more than one zoological complex, the eastern Solandrian and the western Dampierian Provinces of Hedley. It has been considered necessary to include this biogeographical map so that the smaller distribution maps of species may be orientated.

The biogeographical range of the various species differs considerably but with one doubtful exception no species is found both in the temperate and tropical regions. Other species are confined to the warm temperate or the cool temperate, and for some reason yet to be explained some occur only in the Flindersian province of the warm temperate, although some faunal elements of this and the Peronian province do meet in Victoria.

Ecological work has been carried on simultaneously in Western Australia and Victoria (Bennett and Pope, 1953) and more recently in Queensland; New South Wales was worked in 1946 (Dakin, Bennett and Pope, 1948). Molluscs, and particularly limpets, were sent to the National Museum for identification by various workers, and it soon became clear that species, genera and, even in one case, a family have been wrongly identified in the past. Probably this was in part due to the sparse material available to earlier workers. It is obvious that the intense, carefully documented collecting necessary for an ecological survey would reveal new forms and show new localities for known species.

There are necessarily many gaps in the present paper because there are still large areas that are unworked, and some of those that have been broadly surveyed still require more intensive collecting. The whole of Northern Australia and North-Western Australia is untouched. Kangaroo Island, South Australia, is the only part of that State which has been intensely worked; Tasmania is also untouched.

It soon became apparent that identification of limpet species by shell characters alone was a difficult task. Therefore, the author sought other characters which would be constant within a species but specifically different. W. R. B. Oliver (Oliver 1926) gave a lead by using the radula in conjunction with shell characters to define both genera and species. The present work has shown that, with the more extensive material available, radula characters can be used not only for specific determination, but also in separation of true subspecies. Oliver's simple definition of radula components has been used here.

In the families under consideration the radula is composed of recurring sets of teeth arranged on a long basement membrane. In each set there is usually an anterior element of several teeth close together in the middle line (centrals), a posterior element of two or more teeth not meeting in the middle line (laterals) and in some genera one or more small colourless and probably functionless teeth on each margin (marginals).

In these families the number of teeth in the various elements shows constant differences as follows:

Family Patellidae

Centrals. Typically with five, of which the centre tooth may be small or absent. In *Cellana* there are only two.

Laterals. A single pair, each carrying four cusps. *Cellana* has only two cusps.

Marginals. Three pairs, the outer two of which may be very small.

Generalized Radula formula. $3 \rightarrow 1\ (4) \rightarrow (2 \rightarrow 1 \leftarrow 2) \leftarrow 1\ (4) \leftarrow 3.$

Basement membrane. Not segmented except in *Cellana,* in which it shows partial segmentation.

Note: *Cellana* is obviously intermediate in radula characters and suggests that further study including anatomical dissection might prove it to be the stock of *Patellidae* from which *Acmaeidae* sprang.

Family Acmaeidae

Centrals. Always two.
Laterals. Always two pairs.
Marginals. Typically two pairs, but sometimes absent.
Generalized Radula formula. $2 \rightarrow 2 \rightarrow 2 \leftarrow 2 \leftarrow 2.$
Basement membrane. Segmented, each segment carrying a complete set of centrals, laterals and marginals.

In the compilation of this paper it is considered that photographs are much truer and more convincing than drawings and therefore photographs of each species discussed have been included. Radulas are exceedingly difficult to photograph, but I believe that the photographs show the characters claimed in the text. The slightly exaggerated text figure for each species is merely a simplified tracing from the relevant photograph.

The symbols on the maps indicate records of each species as follows:

† = National Museum Collection.
* = In the literature.

Patellanax chapmani (T. Woods) (Pl. VIII, figs. 1 and 2)

Patella chapmani T. Woods, *Proc. Roy. Soc. Tas.,* 1875, p. 157.
Patella octoradiata Hutton (non Gmelin), *Cat. Marine Moll. New Zealand,* 1873, p. 44, No. 201, Pl. 1, Figs. 1-2.
Acmea alba T. Woods, *Proc. Roy. Soc. Tas.,* 1876, p. 155, No. 73.
Acmea sacharina perplexa Pilsbry, *Man. Conch.,* Vol. XIII, 1891, p. 50, Pl. XXXVI, Figs. 69, 71.
Acmea alba Pilsbry, *Man. Conch.,* Vol. XIII, 1891, p. 54, Pl. 42, Figs. 76, 7 and 8.
Patella perplexa Pritchard and Gatliff, *Proc. Roy. Soc. Vic.,* 15, 1903, p. 194.
Acmea octoradiata Hedley, *Proc. Linn. Soc. N.S.W.,* Vol. XXIX, 1904, p. 188; Pritchard and Gatliff, *Proc. Roy. Soc. Vic.,* 18, 1905, p. 65; Verco, *Trans. Roy. Soc. S. Aust.,* Vol. XXX, 1906, p. 209; Chapman, *Proc. Roy. Soc. Vic.,* 25, 1912, p. 186, Pl. XII, Figs. 1 and 2; Suter, *Man. N.Z. Moll.,* 1913, p. 75, Pl. VII, Fig. 6.
Patelloida perplexa Iredale, *Trans. N.Z. Instit.,* Vol. XLVII, 1915, p. 430.
Patella perplexa Peile, *Proc. Mal. Soc. Lond.,* Vol. 15, 1922, p. 16-17, Fig. 4.
Patelloida perplexa Chapman and Gabriel, *Proc. Roy. Soc. Vic.,* 36, 1923, p. 25.
Patella perplexa Iredale, *Proc. Linn. Soc. N.S.W.,* Vol. 49, 1924, p. 238.
Scutellastra chapmani Oliver, *N.Z. Journ. Science and Technology,* Vol. VII, 1924, p. 244.

Shell ovate, somewhat broad behind; apex acute, slightly to the anterior; eight more or less prominent radiating ribs, three anterior and five posterior. Whole shell sculptured with numerous fine radiating lirae which may be interrupted by encircling lines of growth; both ribs and lirae nodulose. Exterior of shell white, scorched with reddish horn flecks, interior white or tinted with pale rose; spatula scracely visible. In young thin shells the exterior colour may show to the interior.

Average dimensions. Length—20 mm. Width—16 mm. Height—6 mm.

The synonymy of this species shows that it was originally described from New Zealand by a New Zealand conchologist, Colonel Hutton. This description and record was based on shells in the Dominion Museum which have since been shown to be incorrectly labelled (Oliver 1924). Tennison Woods, *loc. cit.*, gave a very adequate and unmistakable description of the species. In 1876 he mistook the extreme form with almost even ribs for another species and described it as *Acmea alba*. Iredale (1924) has given a summary of the wide shell variation in this species and has shown that the degree of development of the ribs is due to environment.

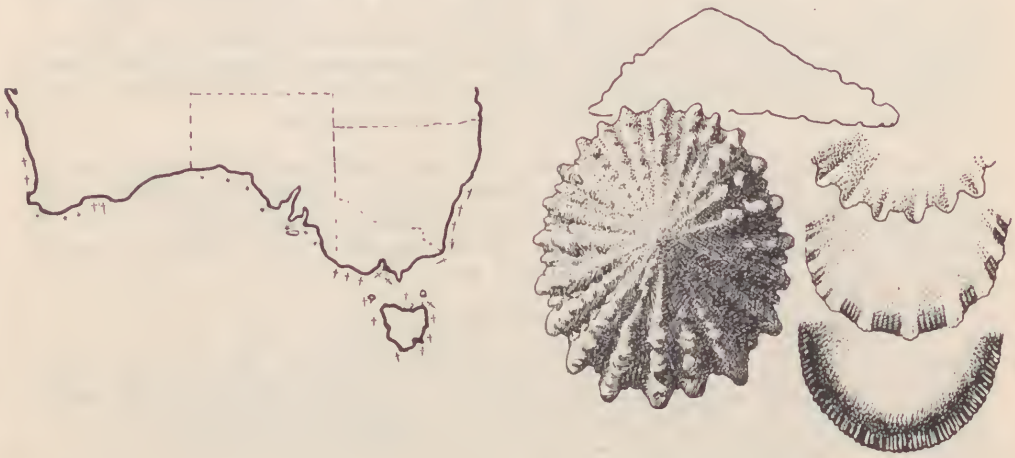
Radula (Pl. VIII, figs. 1 and 2). Both Peile and Oliver give diagrammatic figures of the radula but did not compare it with other members of the genus. The formula is $3 \rightarrow 1 \rightarrow (2 \rightarrow 1 \leftarrow 2) \leftarrow 1 \leftarrow 3$. In this species the median central is very small, flanked by two normal sized teeth. The large single lateral is 4-cusped; the innermost cusp is very small, the third is the largest. There are three typical colourless marginals.

Habitat. This shell is found in the lower littoral zone, living among the algae on the upper surface of rock platforms and boulders. This is a zone of dense algae growth which include the corallines, and the shells of this limpet are often encrusted with the latter and are difficult to see. It is a member of the ocean coastal fauna of New South Wales, Victoria, Tasmania, South Australia and southern Western Australia, including the Recherche Archipelago, but is absent from areas of maximum exposure.

Patellanax peroni (Blainville) (Pl. VIII, fig. 3)

Patella peroni Blainville, *Dict. Sci. Nat.* (Levrault), 38, 1825, p. 111.
Patella diemensis Philippi, *Zeitsch. fur Malak*, 5, 1848, p. 162.
Patella ustulata Reeve, *Conch. Icon.*, Vol. VIII, 1855, Pl. 31, Fig. 88 a, b.
Patella aculeata Reeve (non Gmelin), *ibid.*, Pl. 32, Fig. 90.
Patella squamifera Reeve, *ibid.*, Pl. 32, Fig. 94.
Patella tasmanica T. Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 157.
Patella (Scutellastra) aculeata Pilsbry, *Man. Conch.*, Vol. XIII, 1891, p. 100, Pl. 25, Figs. 20, 21, and Pl. 62, Figs. 71-73.
Patella (Scutellastra) ustulata Pilsbry, *ibid.*, p. 101, Pl. 22, Figs. 11-12.
Patella hepatica Verco (non Pritchard and Gatliff), *Trans. Roy. Soc. S. Aust.*, Vol. 30, 1906, p. 207.
Patellanax squamifera Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 239.
Patellanax squamifera Theile, *Handl. der Syst. Weichtierkunde* Band I, 1931, p. 40.

Shell thick, oval, conical; apex slightly anterior; approximately 24 strong radiating, sub-carinate, rugose ribs, which increase in number with age; interspaces with radiating lirae. Margin irregular due to the projecting ribs making a sharply scalloped edge. Ribs white with interspaces yellow, brown or black. Interior porcellaneous, white, with a faint yellow or brown spatula; margin thin, crenulated, matching the exterior ribbing and colouration.

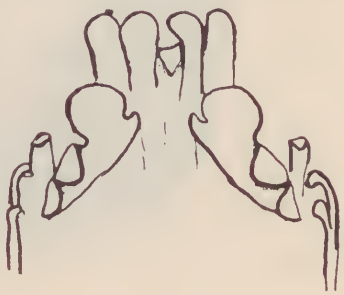


Average dimensions. Length—35 mm. Width—28 mm. Height—15 mm.

Patellanax aquamifera Reeve and *Patellanax hepatica* Verco have been placed in the above synonomy. It is evident that this species is very variable; colour and sculpture of shells from any one locality may differ considerably. At one end is the *squamifera* type with 24 large white ribs interspaced with smaller yellow ones. At the other end is the *peroni* type in which the numerous, almost uniform radials are dark with only an occasional light one.

There is also an extreme variant with uniform radials which are jet black in colour. This is Verco's *hepatica*, which both he and subsequent writers confused with the species now known to be *Patelloida victoriana* Singleton. (See note, p. 243).

The grading of a large series of shells from a single locality such as Lorne showed that all the above forms were present and that there were intermediates which made it impossible to separate them into distinct species. The evidence of the Lorne series was borne out in all other localities where a large series was collected, including localities in Western Australia and New South Wales.



Radula (Pl. VIII, fig 3). The radulas of shells from a number of localities were examined and they proved to be uniform in all details. As the remaining species of the genus can be separated on radula form, this evidence confirms the intergraduation of the shell characters.

Radula formula is $3 \rightarrow 1 \rightarrow (2 \rightarrow 1 \leftarrow 2) \leftarrow 1 \leftarrow 3$. The radula has five centrals, the median one small and possibly functionless. The single laterals bear four cusps, and on either side of these are three functionless marginals. The four cusps of the laterals vary in size; the inner one is very small, and is followed by a large rounded cusp and then two more diminishing in size towards the outer edge. All the teeth are dark brown with colourless bases, except for the marginals, which are entirely colourless. Claude M. Torr, *Trans. Roy. Soc. S. Aust.*, Vol. XXXVIII, 1914, p. 365, figures the radulas of *Patella ustulata* and *P. aculeata* and shows the former with only a single marginal tooth. Whether he had a malformed radula or failed to see the other transparent teeth it is impossible to say. If Dr. Torr's so-called *P. ustulata* is a true representation of the radula of his shell, then it would seem that he had a new species distinct from the present one.

Habitat. Very common on the exposed rock platforms of the lower littoral (Pyura) zone and descending to the sublittorial fringe among the hold-fast of the giant kelp *Sarcophycus potatorum* of New South Wales and Victoria. I have also examined specimens from Tasmania, South Australia and Western Australia, where it occurs in the corresponding algal zone.

Patellanax laticostata (Blainville) (Pl. VIII, fig. 4)

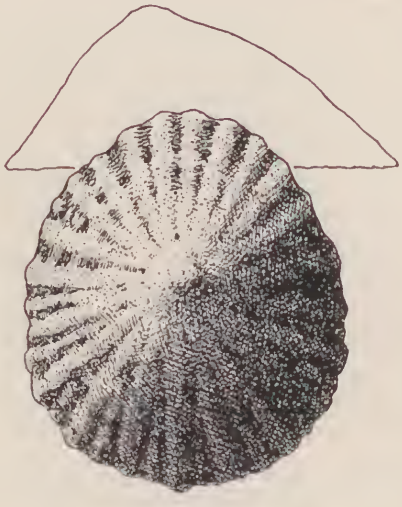
Patella laticostata Blainville, *Dict. Sci. Nat.* (Levrault), 38, 1825, p. 111.
Patella melanogramma Sowerby (non Gmelin), *Genera of Shells, Patella,* Vol. 1, 18, p. 140.
Patella neglecta Gray, *King's Intertropical Survey of Australia,* II, 1826, p. 156, 182, 492.
Patella rustica Menke, *Moll. Nov. Holl.,* 1843, p. 33; *Zeitsch. fur. Malak.,* 1844, p. 62.
Patella zebra Reeve (non Blainville), *Conch. Icon.,* VIII, 1854, Pl. 4, Fig. 7.
Patella (Scutellastra) neglecta Pilsbry, *Man. Conch.,* Vol. XIII, 1891, p. 95, Pl. 20, Figs. 41 and 2; Pl. 58, Figs. 40, 41.
Patella neglecta Gray, *Trans. Roy. Soc. S. Aust.,* Vol. XXXVI, 1912, p. 192.
Patella laticostata Iredale, *Proc. Linn. Soc. N.S.W.,* Vol. 49, 1924, p. 241.

Shell very thick, large, subconical, broader posteriorly; apex slightly anterior, strong, radiating, nodulose, subcarinate ribs, approximately 22 in young individuals but increasing in number with the growth of the shell, interspaces with fine striae. Ribs and striae white with brown interspaces, apex often eroded and white. Interior porcellaneous, white, with the spatula white or fused with red-brown; muscle impression well defined and often pale yellow in colour. Margin sharp, crenulated, matching the exterior ribbing and colouration.

Average dimensions. Length—90 mm. Width—60 mm. Height—30 mm. This species is the largest of the Australian limpets and its radula formula shows that it belongs to *Patellanax* and not *Cellana*, where it has been placed by some recent authors.

Radula (Pl. VIII, fig. 4). The radula formula is $3 \rightarrow 1 \rightarrow (2 \rightarrow 1 \leftarrow 2) \leftarrow 1 \leftarrow 3$. The radula is broad and the teeth are also wide and shovel-shaped. The median central is smaller than the other four. The large lateral has four cusps, the second from the inside being the largest; all the cusps are well defined. The three colourless marginals on each side are very distinct.

Habitat. Found in the zone of the lower littoral in western South Australia and southern Western Australia. The larger shells are often badly eroded, covered with algal growth and may have one or two specimens of *Patelloida nigrosulcata* attached to them.



Cellana solida (Blainville) (Pl. IX, figs. 1 and 2)

Patella solida Blainville *Dict. Sci. Nat.* (Levrault), Vol. 38, 1825, p. 110.
Patella rubraurantiaca Blainville, *ibid.*, p. 111.
Patella limbata Philippi (non Bolten), *Abbild. und Besch., Conch.*, Vol. III, 1849, p. 71, Pl. 3, Fig. 3.
Patella limbata Reeve, *Conch. Icon.*, Vol. VIII, 1854, Pl. 13, Fig. 29 a, b.
Helcioniscus limbata Pilsbry, *Man. Conch.*, Vol. XIII, 1891, p. 143, Pl. 71, Figs. 53-6, and Pl. 17, Figs. 28, 29.
Cellana limbata Hedley, *Journ. Roy. Soc. W. Aust.*, Vol. 1, 1914-15, p. 37.

Shell thick, very large, oval, conical, narrowing anteriorly, apex subcentral; approximately 26 strong, rounded, radiating ribs and distinct encircling growth lines. Colour is light grey or greyish pink with dark brown streaks in the interspaces between the ribs. Interior irridescent, grey in young shells, and yellow, pink or orange in adult shells, with the margin deeper in colour. The dark brown radial lines of the exterior often show through to the interior at the margin, and in young shells over the whole surface. Spatula grey or grey green with the muscle scar orange and very heavy in old shells.

Average dimensions. Length—78 mm. Width—65 mm. Height—34 mm.

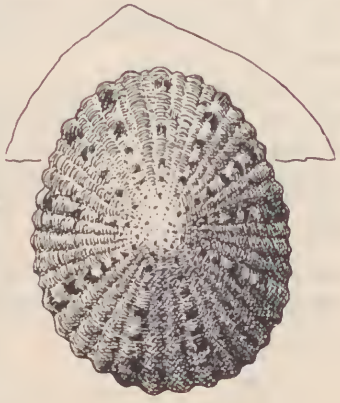
As shown in the above synonymy, Blainville described this species twice, the two descriptions following each other in the text. The first description refers to the less eroded younger and smaller shells, which are always grey on the outside and lack the strongly orange red interior of older shells. The second description, as the name implies, refers to the older, very deeply coloured shells. Iredale (*Proc. Linn. Soc. N.S.W.*, 49, 1924, p. 241) states that the eastern Tasmanian shell is *solida* and is a different shell from the South Australian, which is *rubraurantiaca*. Comparison of the two series in the National Museum does not bear this out as the shells are indistinguishable. Examination of the radulas show that these also are the same, whereas all other radulas of the genus show specific differences.

Radula (Pl. IX, figs. 1 and 2). The radula formula is $3 \rightarrow 1\ (2) \rightarrow 2 \leftarrow 1\ (2) \leftarrow 3$. The typical very long coiled radula has long narrow teeth. The two centrals are simple single cusped teeth; the bicuspid laterals have one long sharp-pointed cusp with a minute secondary cusp nestled into its base, so that when broken off an indentation is left. The three marginals are simple; the inner one is much the larger of the three, with a distinct cutting edge on the turned apex. Dr. Torr (*Trans. Roy. Soc. S. Aust.*, 38, 1914, p. 365, Pl. XX, No. 11) gave a description and figures of the radula of *Helicioniscus limbata* Philippi which differs in a number of points from the present material. This gives no indication of Torr's third median central, and the small cusp of the bicuspid lateral, though very small, is elongated, wedge-shaped, with a distinct base joined to that of the larger cusps.

Habitat. Found in the algal zone of the lower littoral in eastern South Australia, Bass Strait islands, Glennies Group and Wilson's Promontory, Victoria and Tasmania.

Cellana tramoserica (Sowerby) (Pl. IX, figs. 3 and 4)

Patella tramoserica Sowerby, *Cat. Tankerville Coll.*, 1825, p. 30.
Patella variegata Blainville (non Gmelin), *Dict. Sci. Nat.* (Levrault), Vol. 38, 1825, p. 100.
Patella jacksoniensis Lesson, *Zool. "Coquille"*, Vol. II, 1830, p. 418.
Patella tramoserica Lamarck, *Anim. S. Vert.* (2nd ed., Desh), Vol. VII, 1836, p. 47.
Patella tramoserica Reeve, *Conch. Icon.*, Vol. VIII, p. 54, Pl. 13, Fig. 27a.
Patella variegata Reeve, *ibid.*, Pl. 16, Fig. 36a, b, c.
Helcioniscus tramoserica Pilsbry, *Man. Conch.*, Vol. XIII, 1891, p. 142, Pl. 70, Figs. 49, 52.
Helcioniscus melanostomus Pilsbry, *ibid.*, p. 151, Pl. 32, Figs. 67, 68, 69.
Cellana variegata Iredale, *Trans. New Zealand Instit.*, Vol. XLVII, 1914, p. 430.
Cellana tramoserica Iredale, *Rec. Aust. Mus.*, Vol. XIX, 1936, p. 289.
Cellana sontica Iredale, *Aust. Zool.*, Vol. IX, 1940, p. 433, Pl. XXXIII, Figs. 10, 11, 12.



Shell thick, large, conical, slightly broader posteriorly, apex subcentral; sculpture approximately 36 strong, subcarinate, radiating ribs, and numerous fine, closely set encircling growth lines; margin sharp, scalloped. The colour is very variable, and may be orange or pink, patterned with brown and white, or brown, patterned with yellow, orange and white; often every third or fourth rib is darker, giving a striped appearance, and in some the interspaces between the ribs are streaked with dark brown or black. Interior irridescent grey or yellow with the darker exterior colour showing through, particularly near the margin. Spatula white or grey.

Average dimensions. Length—53 mm. Width—45 mm. Height—28 mm.

This species, like many of our Australian limpets, has a long synonymy which has, for many years and by many authors, been recognized and therefore needs no comment. However, this does not apply in the case of *C. sontica* Iredale, a species erected for a shell from southern Queensland. A long series of *Cellana,* collected by Queensland University from the type locality of *sontica,* Caloundra, included specimens which corresponded in all details to the original description and figure of this species. This series showed a continual grading from the typical *C. sontica* to the typical *C. tramoserica.* I took the opportunity while in Sydney, in May 1953, to compare specimens of this series with Iredale's type of *sontica* and there is no doubt that they are identical. Because of the perfect grading between the two species, *C. sontica* must be added to the synonymy of *C. tramoserica.*

Radula (Pl. IX, Figs. 3 and 4). To confirm the evidence of shell characters, radulas of the two extreme forms were mounted and found to correspond in every detail. The radula formula is $3 \rightarrow 1\ (2) \rightarrow 2 \leftarrow 1\ (2) \leftarrow 3$. The two centrals are plain, single-cusped teeth. The laterals are bicusped, having the inner cusp as long as the centrals and with a notch approximately half way down it; the outer cusp is small and deltoid-shaped. There are three small single colourless marginals on either side, the inner one with a hooked edge being much the largest. These marginals are long narrow teeth extending the full length of each tooth block.

Habitat. On exposed rock surfaces in the mid-littoral zone but extending into both the lower and upper littoral zones of eastern South Australia, Victoria, New South Wales and southern Queensland. It is also recorded by May (Illustrated Index of Tasmania Shells, 1923) from the east coast of Tasmania.

Cellana conciliata Iredale (Pl. X, figs. 1 and 2)

Cellana conciliata Iredale, *Aust. Zool.*, Vol. IX, 1940, p. 432, Pl. XXXIII, Figs. 1, 2, 3, 19, 20.

Iredale, in his original description, described both the adult and young shell which he considers the common Cellana in north Queensland. His description is as follows:

"Shell broadly oval medium elevation, anterior slopes a little convex, posterior straight, apex at anterior third. The shell with age broadens out posteriorly without increasing elevation, and forms a large thickened shell all around the internal margin, while the tentacles leave a depression well marked on the shell. Sculpture of very numerous riblets, practically no concentric growth lines visible. Colouration, blue-green with indistinct darker radial bands; inside spatula of various shades of brown becoming paler with age; outside the spatula silvery blue, margin slightly marked with blue.

Length—40mm. Breadth—44 mm. Height—14 mm. Another 44 x 39 x 15.

Type from Keppel Bay, collected by H. Bernhard.

The young shell is elongate oval, thin, transparent, not much elevated. Colouration alternate radial bands of pale greenish and blackish green, at first the pale bands dominant, but with age this is reversed, only narrow stripes of the paler colour being seen. The sculpture is more pronounced, sometimes the ribs showing a slight nodulation.

Length—21 mm. Breadth—15 mm. Height—7 mm. 18 x 14 x 6 mm."

The specimens used for detailed work on the radula were compared with the type specimen and correspond exactly. The shell shows certain constant differences from *tramoserica* and this is borne out in the radula.

Radula (Pl. X, figs. 1 and 2). Radula formula is 3→1 (2) →2←1 (2) ←3. The two centrals are long, plain cusps slightly longer than the bicuspid laterals. The long inner cusp of the lateral is notched at approximately one third from the point. The smaller delta-shaped outer cusp is about one third as tall as the inner one. Three short, stout, colourless marginals, the innermost being the largest. A projection on the basement membrane below each set of marginals gives the appearance of a second indistinctly defined group of marginals. The whole appearance of the teeth is shorter and slightly stouter than those of the radula of *C. tramoserica*.

Habitat. Found at low- to mid-tide level, its southernmost known range being Bargara, Queensland.

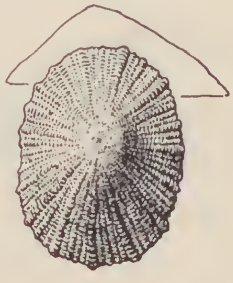
Cellana turbator Iredale (Pl. X, figs. 3 and 4)

Cellana turbator Iredale, *Aust. Zool.*, Vol. IX, 1940, p. 433, Pl. XXXII.

"Shell small, conical, rather regularly oval, elevated, apex at anterior third, eroded, anterior slope straight, posterior convex. Colouration greenish white with few black markings. Sculpture consists of coarse nodulose radials alternating larger and smaller, about twenty-five of each. Inside silvery white, the spatula brownish, no definite marginal markings.

Length—15 mm. Breadth—12 mm. Height—6 mm.

Type from Caloundra, South Queensland."



The present series collected by the Queensland University zoologist are from Caloundra and Cairns. The largest specimen of the present series is 26·5 mm. long by 20 mm. wide. With age the whole shell appears to darken and become overlain with steel grey inside and out. This has the effect of making the shell resemble *C. conciliata* or a dark *C. tramoserica*. It is distinguished from the former by the fawn instead of the yellowish white spatula, and stronger external sculpture, and from the latter by the strong alternately larger and smaller nodulose radials. The number of radials increases from between the older, more pronounced ones.

Radula (Pl. X, figs. 3-4). The radula is quite distinct from all the other species. Radula formula is $3 \rightarrow 1\ (2) \rightarrow 2 \leftarrow 1\ (2) \leftarrow 3$. The two centrals are single-cusped except for a small spur on the outer edge of each tooth near the base. This spur is very clearly seen when the radula is looked at from above. The bicusped laterals have a long inner cusp, with a prominent notch about one-quarter of the way from the tip, and a deltoid cusp which is about a third the height of the inner cusp. The marginals are colourless; the outer one on each side is the largest and most clearly defined.

Habitat. Lower littoral, and frequently covered with Lithothamnian, Queensland.

Patelloida alticostata (Angas) (Pl. XI, figs. 1 and 2)

Patella alticostata Angas, *Proc. Zool. Soc. Lond.*, 1865, p. 56.
Patella costata Angas (non Sowerby), *Proc. Zool. Soc.*, 1867, p. 221.
Acmea costata T. Woods (non Sowerby), *Proc. Roy. Soc. Tas.*, 1876 (1877), p. 50; Pilsbry, *Man. Conch.*, Vol. XIII, 1891, p. 51; Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, Vol. 21, 1908, p. 382.
Acmea alticostata Hedley, *Proc. Linn. Soc. N.S.W.*, Vol. 29, 1904, p. 189; Verco, *Trans. Roy. Soc. S. Aust.*, Vol. 30, 1906, p. 209; *ibid.*, Vol. 36, 1912, p. 183, 197, Pl. 16, Figs. 3, 4; Iredale, *Proc. Zool. Soc.*, 1914, p. 670.
Patelloida alticostata Hedley, *Journ. Roy. Soc. W. Aust.*, Vol. 1, 1916, p. 35.
Patelloida alticostata antelia and *complanata* Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 234.
Patelloida alticostata antelia Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 551.

Shell conical, solid; approximately 18 radiating ribs, subcarinate; apex slightly anterior and usually eroded; margin thin, scalloped. Colour white or grey-green due to algal growth which seems to attack this species very frequently.

Interspaces between the ribs marked with fine black cross-lines which are characteristic of this species. Interior porcellaneous, white, spatula grey and white, with the strong muscle scar tinged with brown. Margin light brown with the black of the exterior showing through on the indentations.

Average dimensions. Length—45 mm. Width—39 mm. Height—19 mm.

Radula (Pl. XI, figs. 1-2). The radula formula is $2 \rightarrow 2 \rightarrow 2 \leftarrow 2 \leftarrow 2$. The centrals are large with pointed spoon-shaped cusps and medium length bases. The inner laterals are very large, with rounded cusps; outer laterals are small, being about one-quarter the size of the inner pair. Bases are short. The marginals are well formed, with curving cusps. The radula segment is square. Radulas, like the shells of this species, are quite distinct and very uniform in appearance. Oliver, following Iredale's lead, separates eastern members of this species from those of southern and western Australia, remarking that the division is more dependent on geography than on anatomical characters. With this latter statement the present author concurs and therefore calls the whole series *alticostata*.

The creation of subspecies on a purely geographical basis is a dangerous practice, and it tends to mask the true boundaries of zoogeographical provinces. In ecological work species and subspecies must be clearly defined.

Habitat. Lives on exposed rock surfaces in the lower littoral. Shells are usually eroded and often partially covered with algal growth. Occurs from Geraldton, Western Australia, to southern Queensland and Tasmania.

Patelloida nigrosulcata (Reeve) (Reeve) (Pl. XI, figs. 3 and 4)

Patella nigrosulcata Reeve, *Conch. Icon.*, Vol. VIII, 1855, Pl. 30, Fig. 84.
Patella stellasformis var. *migrosulcata* Pilsbry, *Man. Conch.*, Vol. XIII, 1891, p. 100, Pl. 61, Figs. 66 and 67.
Acmea petallavecta Verco, *Trans. Roy. Soc. S. Aust.*, Vol. 36, 1912, p. 195, Pl. 15, Figs. 5-7; Pl. 16, Fig. 5.
Patelloida patellavecta Hedley, *Proc. Linn. Soc. N.S.W.*, Vol. 41, 1917, p. 708.

Shell ovate, rather solid, sharply conical, radially grooved, grooves narrow, distant; margin thin, faintly scalloped and conforming to the places of attachment; shell rough, chalk white, grooves more or less black; interior creamy-white, sometimes tinged with brown, spatula rimmed with brown, margin faintly lineated.

Average dimensions. Length—22 mm. Width—16 mm. Height—11 mm.

Verco thought this shell might be Reeve's species but described it as new under the name *Acmea patellavecta*. His description is very full and included a

description and diagrammatic figure of the radula. Verco's suspicion of the shell's identity was confirmed by Hedley, (1917), who quotes the following personal note which he had received from T. Iredale:

"Specimens of Verco's shell have been received at the British Museum and I compared them, with Mr. Edgar A. Smith's assistance; we agree that the identity is absolute."

Radula (Pl. XI, figs. 3 and 4). The radula formula is $2 \rightarrow 2 \rightarrow 2 \leftarrow 2 \leftarrow 2$. The centrals are broad spoon-shaped teeth with pointed cusps. The inner laterals are narrow, with rounded cusps, outer laterals very broad with a wide straight cutting edge. The marginals are wide, with turned-over cusps. All teeth have very short bases and the segments of the radula are twice as wide as long.

Habitat. Generally found attached to other shells such as *Patellanax laticostata*. Southern Western Australia and western South Australia.

Patelloida victoriana (Singleton) (Pl. XII, figs. 1 and 2)

Patella victoriana Singleton, *Proc. Roy. Soc. Vic.*, Vol. 49, 1937, p. 391, Pl. XXIII, Fig. 1, new name for *P. victoriaca* Gat. and Gab.

Patella hepatica Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, Vol. , 1903, p. 194; Verco, *Trans. Roy. Soc. S. Aust.*, Vol. XXX, 1906, p. 207; *ibid.*, Vol. XXXI, 1907, p. 99; Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 240.

Patella victoriae Gatliff and Gabriel, *Proc. Roy. Soc. Vic.*, Vol. 34, 1922, p. 152, Pl. XXIII, Fig. 1.

Singleton's description of this species is as follows:

"Shell elongate ovate, moderately elevated anterior slopes 47 deg., posterior slope 26 deg., nearly flat; sculptured by about 100 depressed subequal radiating riblets, increasing by division, crossed by fine lines of growth, interspaces almost linear. Apex subacute, slightly eroded, pointing anteriorly, situated in the anterior third of the shell. Colour dark brown, the interior white to bluish-white with brown margin. Length—23·7 mm., Breadth—18·9 mm., Height—8·5 mm."

This shell seems to have been a stumbling block to many conchologists. Pritchard and Gatliff referred our species to a Celebes shell with a pre-occupied name, *P. striata*, and Pilsbry erected *hepatica* in place of this name. Later in 1922 Gatliff and Gabriel decided that our shell was not the Celebes shell and erected a new name, *P. victoriae*, but still without description or figure, so their name is invalid.

Singleton finally renamed it in 1937 and gave a full description and figure. Probably the main reason for the difficulty over the name is that two species have been confused and different authors have in reality been discussing different shells. Verco (1906 and 1907) was apparently confusing the fine ribbed dark form of *Patellanax peroni* with this species, for it is unlikely that so careful a worker, with his well known interest in molluscan anatomy, would have overlooked the family characters of *Acmaeidae* which are present in *victoriana*. Verco stated that he considered *ustulata*, *aculeata* and *hepatica* to be conspecific. With this the present author concurs, if it be allowed that the shell Verco referred to as *hepatica* is not the present shell but the dark form of *Patellanax peroni*.

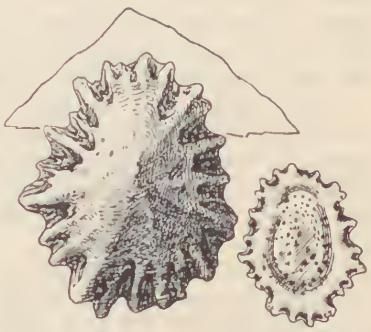
Gatliff, Gabriel and Singleton apparently based their work on shell material only and therefore failed to realize that they were dealing with an *Acmaeid*. However, the animal is typical of this family with a caudal gill plume and radula formula $2 \rightarrow 2 \rightarrow 2 \leftarrow 2 \leftarrow 2$. Also the shell is of the Acmaeid type as it has a dark spatula surrounded by lighter colour and an unbroken dark margin.

Radula (Pl. XII, figs. 1 and 2). The radula has stout, rounded cusped centrals, with the inner laterals approximately the same length. The outer laterals are smaller, with spoon-shaped cusps. The marginals are strong, with hook-shaped cusps. All the teeth have short bases and the segments of the radula are broader than long.

Habitat. In the sublittoral fringe on open rock platforms, amongst the holdfasts of *Sarcophycus potatorum*. This species is hardly ever taken alive because of the difficulty of reaching its habitat and because when eroded it can easily be mistaken for other species and is therefore not collected. Occurs in eastern South Australia, east Victoria to Wilson's Promontory, and Tasmania.

Patelloida saccharina stella (Lesson) (Pl. XII, figs. 3 and 4)

Patella stella Lesson, *Voy. "Coquille" Zool.*, Vol. 2, 1830, p. 421.
Patella stellaris Q. and Gaimard, *Voy. "Astrolobe" Zool.*, Vol. 3, 1834, p. 356, Pl. 71, Figs. 1-4.
Acmea saccharina stellaris Pilsbry, *Man. Conch.*, Vol. XIII, 1891, p. 50, Pl. 36, Figs. 63, 64, 67, 68.
Acmea saccharina Iredale, *Proc. Zool. Soc.*, 1914, p. 670.
Patelloida saccharina Hedley, *Journ. Roy. Soc. W. Aust.*, Vol. 1, 1916, p. 36.
Patelloida saccharina stella Oliver, *Trans. New Zeal. Instit.*, 56, 1926, p. 555.
Patelloida latistrigata Singleton, in part (non Angas), *Proc. Roy. Soc. Vic.*, Vol. 49, Pl. II, 1937, p. 390.



Shell ovate, subconical, thick, eight radiating ribs more prominent than the remainder, apex slightly anterior and usually eroded. Colour grey or white with interspaces between the ribs dark brown. Margin irregular star-shaped due to the projection of the eight ribs. Interior porcellaneous, grey or white, spatula white-dotted or blotched with brown; margin black with white stripes corresponding to the ribs.

Average dimensions. Length—25 mm. Width—20 mm. Height—8 mm.

Radula (Pl. XII, figs. 3 and 4). The radula is stout and the segments almost square. The centrals have rounded cusps and medium length bases. The laterals have very short bases; the inner teeth are very stout with broad spoon-shaped cusps, the outer teeth are small. The marginals are long, narrow and curling.

A check of the material collected by the McCoy Society on Lady Julia Percy Island and described by Singleton (1937) showed that portion of the material he recorded as *Patelloida latistrigata* is in reality this species. This is a considerable extension of any previous recorded range and it will be interesting to note whether further collecting can locate it in the intervening areas or whether it is an outlier. It seems to be entirely absent from Victorian shores east of this point and is unrecorded from South Australia.

Habitat. Found on open rock platforms in the lower littoral zone, Northern Australia, Western Australia, northern New South Wales and Lady Julia Percy Island, Victoria.

Patelloida latistrigata latistrigata (Angas) Angas) (Pl. XIII, figs. 1 and 2)

Patella latistrigata Angas, *Proc. Zool. Soc.*, 1865, p. 154.
Acmaea marmorata T. Woods, *Proc. Roy. Soc. Tas.*, 1875, p. 156; *ibid.*, 1876, p. 53.
Acmaea marmorata Pilsbry, *Man. Conch.*, Vol. 13, 1891, p. 52, Pl. 42, Figs. 66-68.
Helcioniscus latistrigata Pilsbry, *Man. Conch.*, Vol. 13, 1891, p. 143.
Acmaea marmorata Tate and May, *Proc. Linn. Soc. N.S.W.*, Vol. 26, 1901, p. 412.
Acmaea gealei Pritchard and Gatliff (non Angas), *Proc. Roy. Soc. Vic.*, Vol. 15, 1903, p. 198.
Acmaea marmorata Verco, *Trans. Roy. Soc. S. Aust.*, Vol. 30, 1906, p. 210; *ibid*, Vol. 36, 1912, p. 194.
Patella latistrigata Gatliff and Gabriel, *Proc. Roy. Soc. Vic.*, Vol. 21, 1908, p. 382.
Patelloida (Collesellina) latistrigata latistrigata Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 556.
Patelloida latistrigata Singleton, *Proc. Roy. Soc. Vic.*, Vol. 49, 1937, p. 390.

Shell conical, thick, approximately twelve radiating ribs, eight of which are more prominent; apex slightly anterior and usually very eroded; margin thin. Colour light grey, interspaces between ribs dark brown; when eroded the spatula colour often shows through as spots on the apex. Interior porcellaneous, grey-brown, margin striped with black corresponding to rib interspaces; spatula light brown, spotted or blotched with black, and bordered with white.

Average dimensions. Length—14 mm. Width—11 mm. Height—10 mm.

Radula (Pl. XIII, figs. 1 and 2). The radula formula is $2 \rightarrow 2 \rightarrow 2 \leftarrow 2 \leftarrow 2$. The centrals are medium sized, with very long bases. The outer laterals are both narrower and shorter than the rather broad inner pair. The long narrow recurved marginals almost meet behind the centrals. The segments of the radula are long and narrow.

Habitat. Exposed rock surfaces in the mid and upper littoral zone of South Australia, Victoria as far east as Wilson's Promontory, Bass Strait islands and Tasmania.

Patelloida latistrigata submarmorata (Pilsbry) (Pl. XIII, figs. 3 and 4)

Acmaea marmorata var. *submarmorata* Pilsbry, *Man. Conch.*, Vol. 13, 1891, p. 52, Pl. 42, Figs. 49, 70.
Patelloida submarmorata Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 236.
Patelloida (Collisellina) latistrigata submarmorata Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 558.

This subspecies is smaller and flatter and the ribs are more numerous and uniform in size than those of *latistrigata* ss. The interior is grey, with the spatula spotted with dark brown and margined with white. Margin is thin and prickly.

Radula (Pl. XIII, figs. 3 and 4). The radula also shows some differences. All the teeth are longer and the bases of the centrals are slightly shorter, so that the segments of the radula are shorter than in *latistrigata*.

Habitat is similar to that of *latistrigata*. Occurs in southern Queensland, New South Wales and eastern Victoria (Mallacoota).

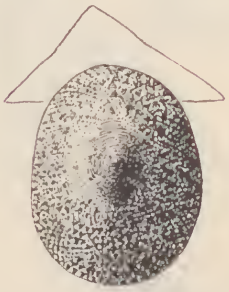
Chiazacmea flammae (Q. and G.)

This is a variable species with a wide distribution from southern Western Australia to southern Queensland. If the radula characters used by Oliver and the present author are a good basis for speciation, then one must recognize a number of distinct subspecies. These subspecies have slight but constant differences in shell pattern and shape of radula teeth, and separate geographical ranges. *C. flammae* is not an inhabitant of the open coast, but prefers the more sheltered waters of bays and inlets. This again has led to confusion, as another species, *Notoacmea granulosa* (see page), a shell of similar appearance from the ocean rock platform, has often been confused with it and occurs in many collections under its name.

Chiazacmea flammea flammea (Quoy and Gaimard) (Pl. XIV, figs. 1 and 2)

Patelloida flammea Quoy and Gaimard, *Voy. "Astrolabe" Zool.*, Vol. 3, 1834, p. 354.
Patella mixta Reeve, *Conch. Icon.*, Vol. VIII, 1855, Pl. 39, Fig. 129.
Acmaea flammea T. Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 511; *ibid.*, 1877, p. 45.
Acmaea flammea Pilsbry, *Mann. Conch.*, Vol. 13, 1891, p. 57, Pl. 37, Figs. 78-83; Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, Vol. 15, 1903, p. 196.
Acmaea cantharus Verco (non Reeve), *Trans. Roy. Soc. S. Aust.*, Vol. 30, 1906, p. 215.

Acmaea mixta Hedley (non Reeve), *Proc. Linn. Soc. N.S.W.*, Vol. 39, 1915, p. 713.
Chiazacmea flammea flammea Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 558.
Acmaea crucis T. Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 52.
Acmaea jacksoniensis var. *mixta* Pilsbry, *Mann. Conch.*, Vol. 13, 1891, p. 58, Pl. 35, Figs. 32, 33.
Acmaea flammea Verco, *Proc. Roy. Soc. S. Aust.*, Vol. 36, 1912, p. 183.
Acmaea irradiata Hedley (non Reeve), *Proc. Linn. Soc. N.S.W.*, Vol. 39, 1915, p. 712.
Patelloida mixta Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 234.



Shell oval, conical, elevated, apex slightly anterior, pointed; basic colour is cream overlaid with a network of fine brown lines and flamed with dark brown, often in the form of a Maltese cross. Interior grey, with the brown flames showing clearly, particularly at the margin; spatula brown in the centre with a light-coloured margin.

Average dimensions. Length—14 mm. Width—11 mm. Height—6 mm.

Radula (Pl. XIV, figs. 1 and 2). Radula formula is 2→2→2←2←2. The centrals have short bases and stout, long-pointed cusps. The inner laterals are as long as the centrals, with broad, rounded cusps. The outer laterals are very small and pointed. The marginals are long and narrow. The segments of the radula are slightly wider than long.

Habitat. On the upper surface of rocks in the lower littoral of sheltered bays and inlets, Tasmania, Victoria, eastern South Australia and southern New South Wales.

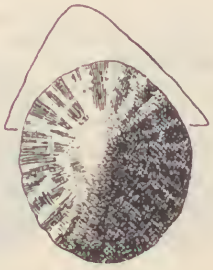
Chiazacmea flammea queenslandiae Oliver (Pl. XIV, figs. 3 and 4)

Chiazacmea flammea queenslandiae Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 561.
Patella jacksoniensis Reeve (non Lesson), *Conch. Icon.*, Vol. VIII, 1855, Pl. 39, Fig. 127.
Tectura jacksoniensis Angas (in part), *Proc. Zool. Soc.*, 1867, p. 220.
Acmaea jacksoniensis Pilsbry, *Mann. Conch.*, Vol. 13, 1891, p. 58, Pl. 42, Figs. 71-75.

Shell conical, depressed, apex subcentral, slopes straight; plane of base arched, broadly elliptical. Outer surface smooth, often eroded, cream in colour, with 13 radiating brown bands, darkest at the margin and each consisting of several lines. Interior porcellaneous, white, with a few brown blotches, spatula light brown. Margin thin, showing the exterior bands.

Average dimensions. Length—14 mm. Width—11 mm. Height—5·5 mm.

Many specimens are higher than the type specimen, some being as much as 8 mm.



Radula (Pl. XIV, figs. 3 and 4). The radula form is typical of *flammae*, but the cusps of the inner laterals have the cutting edge more wedge-shaped than *flammea* ss. Oliver records only one subspecies of *C. flammea* from New South Wales, the small *mimula* Iredale, from the specialized *Crassostrea commercialis* association. However, the recent more intensive collecting has revealed a second form which is identical with *queenslandiae* Oliver.

The subspecies is very common at Point Clare, Brisbane Water, Broken Bay, and is found attached to rocks along with *Syphonaria diemenensis* and *Crassostrea commercialis*. This is apparently a similar type of occurrence to the Queensland type habitat as recorded by Oliver, and confirmed by data with specimens recently collected by R. Kenny of Queensland University.

Habitat. Open rock surfaces, in sheltered bays and inlets of northern New South Wales and southern Queensland.

Chiazacmea flammea mimula (Iredale) (Pl. XV, figs. 1 and 2)

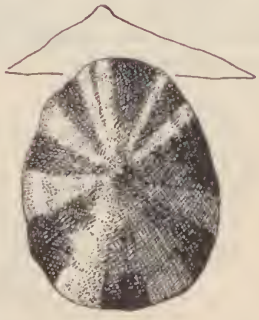
Notoacmea mixta minula Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 235.
Chiazacmea flammea minula Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 561.

This subspecies is very close to *queenslandiae,* as pointed out by Oliver when he erected the latter, but it is retained in spite of the close association of the two forms in New South Wales because of its constant smaller size and higher elevation. The radula also shows slight differences in the shape of the radula segments, which are longer. The marginals have narrower curling cusps, and the inner laterals are more rounded.

Habitat. Intertidal, living on *Crassostrea commercialis* in New South Wales and recorded by Oliver from Tasmania (Blackman's Bay).

Chiazacmea heteromorpha Oliver (Pl. XV, figs. 3-4)

Chiazacmea heteromorpha Oliver, *Trans. N. Zeal. Instit.,* Vol. 56, 1926, p. 562, Pl. 99, fig. and text fig. C.



Oliver gives a very full description of this species and it is reproduced here.

"Shell elevated, conical, apex a little in advance of the centre, the sides convex, the anterior slope considerably steeper than the posterior, the surface rough, the apical portion eroded, but no ribs. Colour of uneroded portion dark brown. Margin irregular in outline, narrowed in front, and truncated anteriorly and posteriorly, the right side expanded behind the apex, the left side fairly regular. Plane of base irregular, evidently in adjustment to the rock-surface. Interior margin glossy, spatula porcellaneous. Spatula white with a brownish centre, margin jet-black, between these pale bluish-brown crossed by 6 broad black bands. Length 18 mm. Breadth 16 mm. Height 8 mm."

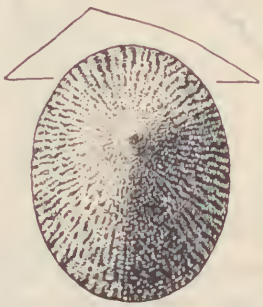
Range of variation. This species undergoes remarkable changes in its life-history. The young shell is perfectly regular in form, narrowed in front, apex in the anterior third, sides straight, finely ribbed, yellow with eight broad black rays. Spatula dark brown. As growth proceeds the margin expands irregularly in adjustment to the irregularities of the rock-surface, and the original regular young shell becomes the eroded apex of the adult. The colour-bands can be distinguished only in the marginal area of the inside, and occasionally on the outside. Generally the anterior three bands of the young shell, which are narrower than the others, are displaced by a simple broad band in the adult shell, thus giving six as the normal number of the adult. The spatula is sometimes obscurely rayed or spotted with brown. Half-grown shells clearly show the changing characters.

Radula (Pl. XV, figs. 3 and 4). Radula formula is 2→2→2←2←2. The centrals have pointed cusps and long bases. The inner laterals are large and broad and the outer ones very small. The marginals are very long, curling inwards above the centrals. The segments of the radula are slightly longer than broad.

Habitat. Upper surfaces of rocks from mid to lower littoral, Facing Island, Yeppoon, Bargara, Elliot River Head, Queensland; and shells only, which appear to be this species, from Cable Beach, Broome, Western Australia.

Chiazacmea cryptalirata sp. n. (Pl. XVI, figs. 1 and 2)

Shell conical, moderately elevated, thin, apex at anterior third, the sides convex, the anterior slope flattened and steeper than the posterior. The surface sculptured with faint broken ribs, which are masked by the colour pattern of red-brown flecks and stripes on a cream ground, overlaid with dark radiating stripes which may form a Maltese cross. Interior porcellaneous and light in colour except for the darker area of the spatula and the rays which can be clearly seen on the interior. The margin is thin.



Radula (Pl. XVI, figs. 1 and 2). Radula formula is 2 → 2 → 2 ← 2 ← 2. Centrals with pointed cusps. Inner laterals large, with triangular pointed cusps, outer laterals very small. Marginals broad, with turned-over cusps. All teeth have short bases and the radula segments are short and broad.

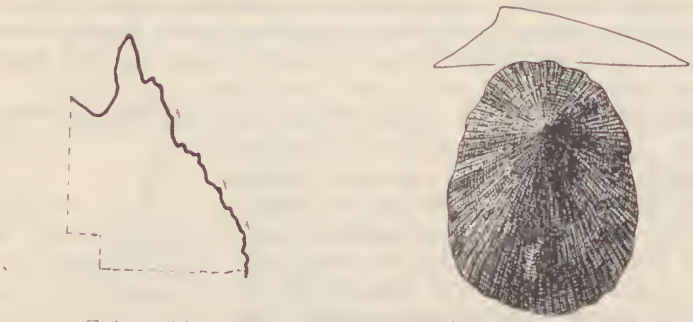
Dimensions of Type. Length—12 mm. Width—9·5 mm. Height—4 mm. Type in the National Museum of Victoria, Collection No. F.13856, Paratypes F.13861.

Habitat. On sheltered rock faces in littoral zone, Point Vernon, Yeppoon (type), and Dunwich, Queensland.

Chiazacmea ater sp. n. (Pl. XVI, figs. 3 and 4)

The description of the type collected by the Zoology School, University of Queensland, and located in the National Museum of Victoria, Collection No. F.13974, is as follows:

"Shell conical, moderately elevated, thin, apex less than a third from anterior margin, the sides convex, the anterior slope steeper than the posterior and slightly concave. The surface rayed with very fine but quite definite radiating ribs, which are much narrower than the interspaces, the width of which increases with distance



from the apex. Colour black; faintly mottled with brown and fawn. Margin thin, dark on the inside. Interior of shell grey-blue with a dark brown spatula."

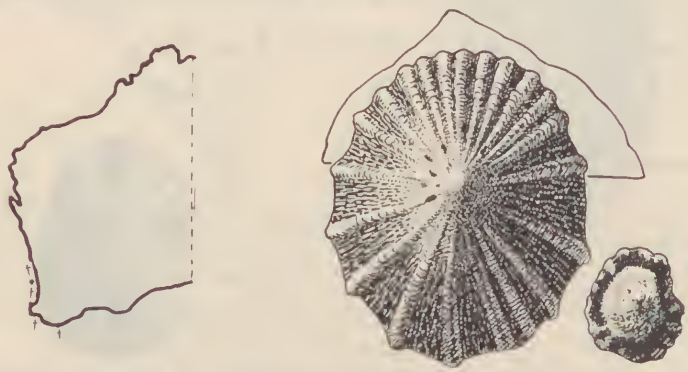
Radula (Pl. XVI, figs. 3 and 4). Radula formula $2 \rightarrow 2 \rightarrow 2 \leftarrow 2 \leftarrow 2$. Centrals with narrow pointed cusps. Inner laterals broad, with V-shaped pointed cusps; outer laterals small. Marginals with distinct curling cusps. Bases of all teeth short, and radula segments slightly wider than long.

Dimensions of Type. Length—11 mm. Width—8·5 mm. Height—3·5 mm.

Habitat. On the under-surface of rocks in mid littoral Bargara (type), Yorkeys Knob, Cannonvale, and Flat Top Island, Queensland.

Notoacmea onychitis (Menke) (Pl. XVII, figs. 1 and 2)

Patella onychitis Menke, *Mulluscorum Novæ-Hollandiæ*, 1843, p. 34.
Patella onychitis Hedley, *Proc. Roy. Soc. W. Aust.*, 1, 1916, p. 36.



Shell conical, solid, ovate convex with 20 strong rounded radiating ribs, eight at anterior and close together and remainder evenly spaced; numerous fine encircling growth lines; apex subcentral; margin thin and crenulated. Blue-black between the ribs, flecked with cream, ribs cream, apical portion cream-flecked, with elongated brown marks. Interior porcellaneous, white, with a light brown spatula; margin striped with brown corresponding to the dark portions of the exterior.

Most shells of this species are very badly eroded and the typical exterior sculpture and colour pattern obliterated.

In eroded shells the apex is white with the remainder of the shell dark brown or black, more or less striped with white, depending on the depth of erosion. In such shells the margin is almost entire, but usually shows the dark bands on the interior.

Average dimensions. Length—19 mm. Width—16 mm. Height—10 mm.

Radula (Pl. XVII, figs. 1 and 2). The typical Notoacmid radula has centrals with stout pointed cusps and long bases. The inner laterals are shorter than the centrals, with rounded spoon-shaped cusps; the outer pair are shorter still, but as wide, with wedge-shaped cusps. The bases of the laterals are short. The radula segments are about one and a half times longer than wide.

Hedley listed this species in his West Australian list but without any comment beyond the original reference. It therefore seems probable that this species has not been recognized since Menke's description was written.

In 1950 Mrs. Loisette Marsh was working on the shore ecology of the Perth area and during the course of this work she collected a large series of patelliform gastropods, which she forwarded to the National Museum of Victoria for identification. This material included a large series of specimens of a species not immediately recognized by the author. Anatomical examination showed it to belong to the Acmaeidae and the radula formula $0 \rightarrow 2 \rightarrow 2 \leftarrow 2 \leftarrow 0$ placed it in the genus *Notoacmea*. No species of *Notoacmae* listed by Oliver or later authors correspond to this shell, but it was found that Menke's description of *Patella onychitis* fitted it very well, and so it is referred to that species.

Habitat. Mrs. Marsh's specimens from a number of localities are all listed as coming from the wave notch on vertical rock faces one to three feet above reef flat. South-western Western Australia.

Notoacmea granulosa sp. n. (Pl. XVII, figs. 3 and 4)

This limpet, which is found in the upper littoral of exposed ocean platforms, has been confused with *Chiazacmea flammea* (or one of its subspecies) in most Victorian collections. The confusion has probably arisen because this species may carry a Maltese cross which is very similar to that of some forms of *C. flammea*. Examination of the radula, which is of the *Notoacmea* type and intermediate in form between *N. mayi* and *scabrilirata*, separates it from *Chiazacmea*. Also this is an inhabitant of the upper littoral of ocean coasts, whereas *Chiazacmea flammea* is only found in the quiet bays and inlets near low-tide mark. The description of the type from Warrnambool is as follows: Shell thick, conical, high apex slightly

anterior, anterior slope steep and almost straight; posterior slope convex, surface granulose, with faint radiating ribs. Colour grey, flecked with darker grey and brown; the flecks near the margin may be elongated into short stripes that show through to the inside. Spatula dark blue or brown, region between spatula and margin lighter in colour. Usually superimposed on the interior pattern is a bluish black Maltese cross which may show through to the exterior.

Dimensions of Type. Length—14·5 mm. Width—10 mm. Height—13 mm. Type in National Museum of Victoria, No. F.16131, Paratypes No. F.5834.

Radula (Pl. XVII, figs. 3 and 4). The radula has the Notoacmea formula, 0→2→2←2←0. The centrals are stout and long with long bases. The inner laterals are nearly as long as the centrals and the outer half their length. All are spoon-shaped with rounded ends and short bases. The radula segment is longer than broad.

Habitat. Vertical surfaces of exposed rock faces in the upper littoral zone of ocean platforms, from Cape Bridgeway to Wilson's Promontory, Victoria, and Kangaroo Island, South Australia.

Notoacmea mayi May (Pl. XVIII, figs. 1 and 2)

Notoacmea mayi May, *Illust. Index Tasmanian Shells*, 1923, p. 100, Pl. 22, Fig. 33.
Acmaea cantharus T. Woods (non Reeve), *Proc. Roy. Soc. Tas.*, 1877, p. 45.
Notoacmea (*Notoacmea*) *mayi* Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 571.

Shell thick, domed, apex at anterior margin, anterior slope steep, posterior slope convex, surface faintly granulose. Colour grey-white, mottled with dark grey-brown. Interior black with a white or partially white spatula.

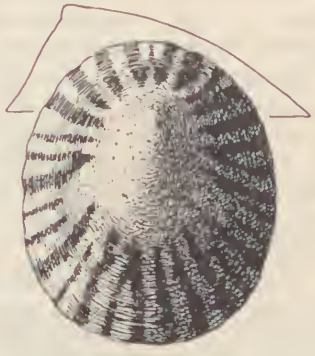
Average dimensions. Length—18 mm. Width—13 mm. Height—7 mm.

Radula (Pl. XVIII, figs. 1 and 2). The radula formula is 0→2→2←2←0. Centrals medium length, stout, with pointed cusps and short bases. Laterals with short bases, the inner pair much longer than the small deltoid, outer cusps. Segments of radula longer than wide.

Habitat. On upper and vertical surfaces of ocean platforms in upper littoral in Tasmania, and Victoria, from Cape Bridgewater to The Nobbies, Phillip Island.

Notoacmea petterdi (T. Woods) (Pl. XVIII, figs. 3 and 4)

Acmaea petterdi T. Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 155.
Tectura septiformis Angas (non Quoy and Gaimard), *Proc. Zool. Soc.*, 1867, p. 520.
Acmaea petterdi Pilsbry, *Man. Conch.*, Vol. 13, 1891, p. 54.
Notoacmea petterdi Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 235.
Notoacmea (Notoacmea) petterdi Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 574.



Shell broadly elliptical, domed, posterior slope arched, anterior slightly convex, steep. Apex in anterior fourth. Ornamented with 28 fine radiating thread-like ribs extending from apex to margin, interspaces several times wider than the ribs. The whole with concentric growth lines. Colour cream, with about 40 light-brown radiating bands. Inside shining, dark; spatula brown, dark and light blotched; surrounding area bluish; margin thin, dark brown, outer edge banded with white.

Average dimensions. Length—20 mm. Width—16 mm. Height—7 mm.

Radulas (Pl. XVIII, figs. 3 and 4). Radula segments are slightly longer than broad. The centrals are very long and pointed. The inner laterals are two-thirds the length of the centrals and the outer ones one-third smaller again and deltoid in shape. This is a very uniform species which is quite distinct, both in shell form and radula, from all other members of the genus.

Habitat. Usually found in colonies on the shaded side of vertical rock faces on ocean coasts. Upper littoral of north-west Tasmania, Victoria, New South Wales and southern Queensland.

Notoacmea septiformis scabrilirata (Angas) (Pl. XIX, figs. 1 and 2)

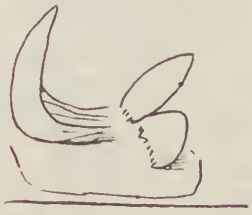
Acmaea scabrilirata Angas, *Proc. Zool. Soc.*, 1865, p. 154.
Tectura scabrilirata Angas, *Proc. Zool. Soc.*, 1867, p. 220.
Acmaea septiformis T. Woods, *Proc. Roy. Soc. Tas.*, 1876, p. 50.
Acmaea scabrilirata Pilsbry, *Man. Conch.*, Vol. 13, 1891, p. 56.
Acmaea septiformis Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, Vol. 15, 1903, p. 195; Verco, *Trans. Roy. Soc. S. Aust.*, Vol. 30, 1906, p. 215.
Notoacmea flammea Iredale (non Quoy and Gaimard), *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 235.
Notoacmea flammea diminuta Iredale, *Proc. Linn. Soc. N.S.W.*, Vol. 49, 1924, p. 235.
Notoacmea (Notoacmea) septiformis scabrilirata Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 573.

Shell thin, subconical; apex at anterior third; anterior slope concave, short, posterior convex; sculpture with many fine beaded radials, interspaces wider than ribs. Colour cream, overlaid with a reticulate or raised pattern of brown. Interior

white with the thin margin showing the exterior pattern, spatula cream or light brown.

Average dimensions. Length—14 mm. Width—10 mm. Height—4 mm.

Radula (Pl. XIX, figs. 1 and 2). The radula has long centrals with short bases. The inner laterals are nearly as long as the centrals; the outer pair are shorter and deltoid in shape. The radula segment is square. Without a series of *N. septiformis* ss. it is impossible to judge the extent of the variation between the two subspecies, so until such time as we have a series it seems better to follow Oliver's division, although he himself seems in some doubt as to *scabrilirata's* validity.



Habitat. In colonies under stones, lower littoral of South Australia, Victoria, Tasmania, and New South Wales as far north as Sydney.

Notoacmea alta Oliver (Pl. XIX, figs. 3 and 4)

Notoacmea (*Conacmea*) *alta* Oliver, *Trans. N. Zeal. Instit.*, Vol. 56, 1926, p. 579, Pl. 99, Fig. 6.

Acmea conoides Pritchard and Gatliff (non Quoy and Gaimard), *Proc. Roy. Soc. Vic.*, Vol. 15, 1903, p. 195; Verco, *Trans. Roy. Soc. S. Aust.*, Vol. 30, 1906, p. 214.

Shell conical, elevated; apex subcentral, acute; anterior slope nearly straight, posterior slope regularly arched. Margin sharp; plane of base arched. Shell smooth, with concentric growth-lines. Black, with 18 pale green bands radiating from apex; colour-bands show on interior, which may be either light or dark brown, with an ill-defined spatula.

Average dimensions. Length—11 mm. Width—9 mm. Height—7 mm.

Radula (Pl. XIX, figs. 3 and 4). Radula has very short, broad teeth with short bases. The centrals have spoon-shaped cusps and the inner laterals are approximately the same length. Outer laterals are one-third as long, and deltoid in shape. The radula segments are wider than long.

Habitat. Living on the shells of *Brachyodontes rostratus* at mid littoral. Most shells are eroded and uniform grey-brown in colour. South Australia and Victoria.

Acknowledgements

The author is indebted to Mrs. B. Marsh of the University of Western Australia, to Mr. R. Kenny, Mr. R. Endean and Professor Stephenson of Queensland University, and to Miss Isobel Bennett and Miss Elizabeth Pope of Sydney, for making the specimens and notes of their ecological surveys, in their respective States, available.

To the Director, Dr. Falla, and Conchologist, Mr. R. K. Dell, of the Dominion Museum, Wellington, New Zealand, for the loan of W. R. B. Oliver's original material for comparison with the present specimens.

To Mr. Wallace Hastie, C.S.I.R.O. Forest Products, Mr. L. Bailleau, Melbourne Technical College, for photographing radulas; to Mr. G. J. Browning for the beautiful shell drawings.

To Mr. C. W. Brazenor, Assistant Director, National Museum of Victoria, for reading the paper and helping with photography.

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